eurythermal; they acclimated successfully to a relatively wide range of temperatures (12-21°C) and generally survived short-term exposure to acute temperature increases and decreases that are probably greater than the fish would normally encounter in the wild. However, in some areas within their range, delta smelt may be exposed to heated effluents and/or entrained in power plant cooling system water diversions where temperatures may reach 30°C (R. Pine, FWS, pers. comm.); our results strongly suggest that such exposure would be lethal to delta smelt. Furthermore, compared to a number of other delta fishes, delta smelt are more sensitive to acute temperature increases. Table 1 compares the CT_{max} of delta smelt to values measured for other fishes using the same methods and similar rates of temperature change. Splittail and inland silverside tolerated substantially greater increases in temperature. Even chinook salmon smolts acclimated to a slightly lower temperature had higher CT_{max}.

Table 1
COMPARISON OF CT_{max} OF DELTA SMELT AND OTHER DELTA FISHES

Species	Acclimation Temperature (°C)	CT_{max} (°C)	Source
Delta smelt	12	21	Swanson & Cech (1995)
	17	25	
	21	28	
Inland silverside	17	31	Swanson & Cech (1995)
Chinook salmon	16.5	26-27	Swanson & Cech (1995)
Splittail			
Young-of-Year	17	31	Cech & Young (1995)
	20	32-33	
Juvenile	12	21	
	17	29	
Subadult	12	22	
	17	29	

Table 2
CHRONIC UPPER SALINITY TOLERANCE LIMITS OF DELTA SMELT
(Mean ± SD)

Temperature (°C)	Life History Stage SL (cm)	Upper Salinity Limit (ppt)
17	Juvenile 3.7 ± 0.3	18.7 ± 1.8 (n=15)
17	Subadult/Adult 5.9 ± 0.3	19.1 ± 2.1 (n=14)
21	Juvenile 3.7 ± 0.4	19.2 ± 1.9 (n=10)

Salinity Tolerance

Chronic salinity tolerance of delta smelt was measured for juveniles, subadults, and adults in 17°C and for juveniles in 21°C. In these experiments, individual fish were subjected to a gradual increase in salinity (2 ppt/12 h), and the tolerance limit was defined as the maximum salinity the fish survived for 12 hours. The slow increase in salinity allowed the fish to physiologically adapt to the changing osmoregulatory demands; therefore the tolerance limit represents the maximum osmoregulatory capacity of the fish for salinity increase.

Delta smelt tolerated chronic exposure to salinity from 0 ppt (fresh water) to 19 ppt (about 55% sea water) (Table 2). Neither acclimation temperature (17 and 21°C) nor fish size affected salinity tolerance.

The results show that delta smelt are euryhaline and that their osmoregulatory capacity is fully developed by 3 months post-hatch when the juveniles were tested. Furthermore, delta smelt are able to tolerate higher salinities than those in which they have been collected to date, suggesting that salinity is not the factor that limits their distribution to fresh and slightly brackish waters. The chronic salinity tolerances of delta smelt measured in these studies were similar to those measured for young-of-the-year and juvenile splittail (Cech and Young 1995).

Implications for Management

Moyle *et al* (1992) reported that delta smelt are apparently extremely sensitive to estuarine conditions, but the relationships between specific environmental conditions in the estuary and delta smelt abundance have not been well defined. The results of these and other ongoing studies in our laboratory can be used to define how temperature and salinity may limit delta smelt distribution and how, within the fish's range, these factors affect survival, physiology, and behavior. As an example, results of the CT_{max} experiments show how anthropogenic temperature fluctuations may adversely and disproportionately impact delta smelt. This type of information contributes to definition and management of dellta smelt critical habitat and improved protection of this threatened fish.

Acknowledgments

This study was funded by the California Department of Water Resources (contracts B-59449 and B-58959). We thank R. Mager and S.I. Doroshov (Department of Animal Science, UC Davis) for their help developing techniques for collection of delta smelt. We also thank the California Department of Fish and Game, particularly D. Sweetnam, G. Aasen, J. Lott, and the Bay/Delta boat crew, for their invaluable cooperation and assistance collecting delta smelt. P. Young (Department of Wildlife, Fish, and Conservation Biology, UC Davis), a number of undergraduate student assistants, including D. Shigematsu, C. Porter, S. Cummings, D. Irwin, M. Thibodeau, and NSF Young Scholars, S. Tannen, S. Aren, and J. Khoo, helped with fish collection, fish care, and data collection.

Literature Cited

Cech, J.J. Jr, and P.S. Young. 1995. Environmental tolerances and requirements of the Sacramento splittail, *Pogonichthys macrolepidotus* (Ayres). Final Report, Interagency Ecological Program for the San Francisco Bay/Delta. 56 pp.

Moyle, P.B., B. Herbold, D.E. Stevens, and L.W. Miller. 1992. Life history and status of the delta smelt in the Sacramento-San Joaquin Estuary, California. *Trans. Am. Fish. Soc.* 121:67-77.

Swanson, C., and J.J. Cech, Jr. 1995. Environmental tolerances and requirements of the delta smelt, *Hypomesus transpacificus*. Final Report, California Department of Water Resources. 77 pp.

Suisun Marsh Diversion Screening Program

Frank Wernette, Department of Fish and Game

Suisun Marsh entrainment studies in 1981 and 1982 identified 34 fish species in Montezuma Slough that were vulnerable to entrainment into unscreened diversions serving managed wetlands in the marsh. Species included chinook salmon, striped bass, and delta smelt. Based on those data, the Fish and Wildlife Service and Marine Fisheries Service incorporated related conditions in a Corps of Engineers regional maintenance permit for Suisun Resource Conservation District and the Department of Fish and Game. The primary goal was to reduce entrainment of winter-run chinook salmon and delta smelt. The Suisun Marsh Diversion Screening Program was begun to help fulfill those permit conditions, which were developed through formal consultation under Section 7 of the Federal Endangered Species Act with the Marine Fisheries Service and Fish and Wildlife Service.

The screening program consists of an extensive diversion assessment element and a fish screen installation element. The assessment element consists of an evaluation to determine whether diversions can be eliminated, downsized, or consolidated; a fyke-net study of fish entrainment into 15 diversions (selected annually); and a mark/recapture evaluation using coded-wire-tagged chinook salmon.

Implementation of this screening program will also help address mitigation needs described in a DWR/DFG agreement to offset impacts associated with the State Water Project, and meet objectives outlined in the State Water Resources Control Board's May 1995 Water Quality Control Plan for the San Francisco/Sacramento-San Joaquin Estuary and the Central Valley Project Improvement Act to reduce impacts to anadromous and special-status fish by screening unscreened diversions. Program implementation will also facilitate addressing mitigation needs associated with the Tracy Fish Agreement and help guide screening funded through Category III.

The program, and the environmental documentation associated with it, will help expedite the permitting process so that screen installations funded from any of the above sources can proceed as rapidly as possible.

The SWRCB 1995 Water Quality Control Plan lists the reduction of losses of all life stages of fishes to unscreened water diversions as a high priority action. The proposed screening program is consistent with that level of emphasis. One goal of the Water Quality Control Plan is to increase transport of fish, such as delta smelt, into Suisun Bay. Screening diversions will help protect fish transported into this area. The screening program will work synergistically with the Water Quality Control Plan to begin the recovery of fish populations.

Significant efforts were already underway through the DWR/DFG agreement and the CVPIA to install screens to prevent entrainment of fish in the estuary, particularly chinook salmon. The screen recently installed on Fish and Game's Grizzly Slough intakes is an example of that effort.

In the long term, screening will assist in recovery of winter-run chinook salmon, delta smelt, and splittail populations, assist in reducing impacts to other salmonids, and may help avoid future listings. Screening will ensure the long-term maintenance of seasonal wetlands in Suisun Marsh and ensure that habitat is maintained for a diverse assemblage of wildlife, including listed species such as salt marsh harvest mouse. Consistent with the ecosystem approach, the long-term viability of these important wetlands (at no serious risk to fish) will ensure that habitat is available for waterfowl and the numerous other water-dependent species.

A key to the success of the program will be the interagency involvement in various phases of the program such as selection of diversions for sampling, development of sampling protocol, and selection of high-priority diversions for screening.

In October 1995, an interagency team, along with stakeholder representatives and their biological consultants, will inspect diversions in the Suisun Marsh to select those for future sampling and to recommend 5-10 diversions for immediate screening.

New Interagency Program Home Page

Karl Jacobs, Department of Water Resources

Looking for data? The Interagency Program Home Page is now on-line! The Interagency Program file server uses the World-Wide Web to provide bay/delta information to researchers. Besides providing field data, the file server uses the versatility of hypertext to provide:

- A bibliography of current and historical documents (digital copies of some will eventually be available);
- Lists of Interagency Program personnel;
- Background on the organization and how it is structured.

Major sections of the home page are still under construction. We are adding: more background information on bay/delta biology, data summaries and analysis results from the monitoring programs, and data needed to more fully understand the estuary.

Field data are organized by program element; metadata are also provided. The field data are in a comma-delimitered text format, and format files are included to provide data users with the structure of the text files. The first five fields of the data files are: (1) RKI number, (2) station ID, (3) date, (4) time, (5) depth. Maps showing sampled locations and general information are also included.

Although not all our data have been placed on the server, most should be available by the end of November. Current work on the data portion includes placing data on the server, helping staff format data, developing a Wide Area Information Server interface, and upgrading communications to the server. Work is also underway to develop telephone modem access to the server.

We want your comments. Pass your recommendations on to the Webmaster or your representative on the new Data Utilization work team. Select the "Webmaster" button (mdng@water.ca.gov) on the home page or call Murray Ng at 916/227-1309.

The home page is accessed on the Internet using World-Wide Web browsers such as Mosaic, Netscape, or Lynx. The address is http://wwwiep.water.ca.gov.